Technische Universität Braunschweig

IFAS Institut für Flugantriebe und Strömungsmaschinen

Master Thesis

Large-Eddy Simulation of Hydrogen–Air Rotating Detonation Combustors for Sustainable Aviation

Duration: 6 Months

Anthropogenic greenhouse gas emissions, mainly from fossil fuel combustion, are the primary driver of global warming and climate change. To limit global temperature rise to 1.5°C by 2050, a rapid shift toward a zero-carbon energy system is essential. Despite the growth of renewables and electrification in sectors like power generation and long-distance transportation, thermochemical energy conversion remains crucial.

Hydrogen-fueled Rotating Detonation Combustors (RDCs) offer a promising alternative to conventional gas turbine combustors due to their potential for higher thermodynamic efficiency and reduced pollutant formation. In an RDC, a continuously propagating detonation wave replaces the deflagration process of conventional combustion, enabling near-constant-volume heat release and potentially higher pressure gains. However, the complex, multi-scale coupling of injection, turbulent mixing, and detonation propagation in hydrogen–air mixtures is not yet fully understood. The extreme operating conditions limit experimental diagnostics, making high-fidelity numerical simulations a critical tool for investigating RDC physics and supporting future design efforts.

The primary goal of this thesis is to numerically investigate the hydrogen–air RDC testbench configuration from TU Berlin [1] (see also https://www.tu.berlin/RDC) using high-fidelity Large-Eddy Simulations (LES). Specific objectives include:

- Develop and validate an LES setup for simulating hydrogen–air RDC operation.
- Characterize key flow features such as detonation wave and reflected waves and evaluate overall performance.
- Compare results with available experimental data for validation and physical insight.
- Analyze the influence of and operating conditions on detonation wave propagation and wave stability.

Requirements:
• High interest in fluid mechanics and CFD
• Proficient in Linux command line
• Proficient in programming (C++, Python)
• Proficient in English and motivated to work in team

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[1] P. C. Nassini, A. Andreini, and M. D. Bohon, Combustion and Flame, vol. 258, p. 113050, 2023, doi: 10.1016/j.combustflame.2023.113050.